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(54) **Transponders, interrogators, systems and methods for elimination of interrogators  
synchronization requirement**

Antwortgerät, Abfragegeräte, Systeme und Verfahren zum Ausschluss von Abfrager-  
Synchronisations-Erfordernissen

Transpondeurs, interrogateurs, systèmes et procédés pour éliminer les exigences de synchronisation  
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(56) References cited:  
**EP-A- 0 301 127** **EP-A- 0 600 374**  
**US-A- 5 287 112**

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## Description

## FIELD OF THE INVENTION

[0001] This invention generally relates to a fast read/write Radio Frequency Identification (RFID) System. More specifically, the invention relates to an RFID system of the type defined in the precharacterizing portion of claim 1 and to a method for communicating between the components of such a system. A system of the type mentioned above is disclosed in EP-A-0 301 127, which is equivalent to US-A-5 053 774.

## BACKGROUND OF THE INVENTION

[0002] Heretofore, in this field, a powering antenna has often been provided with the interrogator in addition to the communicating antenna. This powering antenna is provided for the powering of a transponder not having its own internal power supply. The powering antenna may be a high Q-factor antenna to effect maximum power transfer to the transponder. Because of the flexibility afforded by having a separate power antenna in the interrogator, which may be optimized for power transfer to the transponder, the transponder antenna may be optimized for communicating with the interrogator's communicating antenna. An example of this type of system is given in U.S. Patent No. 4,550,444 by Uebel and in U.S. Patent No. 4,912,471 by Tyburski et al. In such systems the RF coupling can be separately designed for the power transfer link and the communications link. The disadvantage in such a system is the inherently greater cost and size involved in a transponder having two separate circuits for powering and communicating. Another known technique allowing for somewhat optimized powering and communication links is to provide separate transmit and receive antennas in the transponder. In this way the downlink (i.e., the communication link from the interrogator to the transponder) can be designed for efficient power transfer. Because the transponder is desirably compact and power-efficient, the uplink (i.e., the communication link from the transponder to the interrogator) can be optimized to the transponder's transmit antenna. Communication can still be effectively carried out over the downlink because of the lesser need for power and cost efficiency in the interrogator transmitter design. An example of this type of system can be found in U.S. Patent No. 3,713,148 by Cardullo et al. As before, the disadvantage in such a system is the inherently greater cost and size involved in a transponder having two separate circuits, this time for receiving and transmitting.

[0003] Yet another known technique is described in U.S. Patent No. 5,053,774 by Schuermann, et al. In this technique, communication and power transfer is preferably accomplished by a single resonant circuit in each of the interrogator and the transponder thereby minimizing cost, size and power efficiency. The resonant circuit in each of the interrogator and the transponder is used for both communication and power transfer in this prior art. For optimal power transfer the prior art device uses highly tuned, high Q-factor resonant circuits. Because in this technique the same resonant circuit is used in each of the interrogator and transponder for powering and/or bidirectional data communication, interrogators that are operating in close proximity to each other must be synchronized so that the RF power transmission phases, or powering signals do not interfere with the communication signals. In the case of interrogators and transponders that communicate bi-directionally, the data transmissions from the interrogators must also be synchronized so that a data transmission from one interrogator to a transponder does not interfere with the generally lower amplitude data transmission from a transponder to another interrogator.

## SUMMARY OF THE INVENTION

[0004] The present invention overcomes the difficulties described above in that it allows the use of a single set of circuitry in each of the interrogator and the transponder for transmission and reception of both powering and communication signals without the need for synchronization between interrogators.

[0005] According to a first aspect of the present invention a system of the type mentioned in the beginning is provided which has the features of the characterizing portion of claim 1.

[0006] According to a second aspect of the present invention a method is provided which comprises the steps defined in claim 14.

[0007] In the preferred embodiment of the present invention, as in the '774 patent by Schuermann, a single resonant circuit is implemented in each of the interrogator and the responder for maximum efficiency of cost, size, and power consumption. The present invention, however, also eliminates the synchronization requirement for adjacent interrogators. The interrogator sends a powering burst to the transponder during which the interrogator and transponder are tuned with high Q-factor resonant circuits of a frequency  $f_1$ . The interrogator then begins to transmit WRITE data to the transponder using pulse width modulation (PWM), pulse position modulation (PPM), frequency-shift keying modulation (FSK), or another type of modulation. For PPM or PWM, the interrogator would transmit the modulation using frequency  $f_1$ . For FSK, frequencies  $f_1$  and  $f_4$  might be used. For receiving PPM or PWM modulation, the transponder would preferably keep its resonant circuit at frequency  $f_1$  and tuned with a high Q-factor. For receiving FSK, the transponder pref-

erably adapts itself by lowering the Q-factor of its resonant circuit. The transponder is thus more able to interpret the larger bandwidth FSK signal of frequencies  $f_1$  and  $f_4$ . The transponder's resonant circuit preferably adapts itself to the center of the FSK frequencies. The interrogator receiver preferably has a passband characteristic that is symmetric about  $f_2$  and  $f_3$ . The filter pass band is preferably either above or below the power transmission frequency  $f_1$ . For an FSK system, the filter passband is further preferably above or below the FSK frequency,  $f_4$ . If a separate receive antenna is provided in the interrogator, this receive antenna may remain a low Q-factor antenna.

## BRIEF DESCRIPTION OF THE DRAWINGS

10 [0008] In the drawings:

Fig. 1 is a block circuit diagram of the preferred FSK system embodiment;

Fig. 2 is a block circuit diagram of the preferred PWM system embodiment;

Fig. 3 is a timing diagram of the preferred embodiment;

Fig. 4 is a frequency spectrum illustrating the power spectrums for a first preferred FSK embodiment;

Fig. 5 is a frequency spectrum illustrating the power spectrums for a first preferred PWM embodiment;

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0009] Fig. 1 shows a transponder arrangement 10 comprising an interrogator 12 and a responder or transponder 14. The interrogator 12 preferably comprises a control circuit 16 which controls the actions of the interrogator circuitry. The control circuit 16 causes the modulator 48 to generate either the powering frequency  $f_1$  or the second communication or "Write" frequency  $f_4$ . In the illustrated FSK embodiment the first and second frequencies  $f_1$  and  $f_4$  are used to represent two logic states of the WRITE data while the powering frequency  $f_1$  is used as a powering signal. FSK keying is accomplished by control circuit 16 controlling modulator 48 to open and close a switch 50a thereby changing the resonant frequency of the resonant circuit 28 by connecting a capacitor 52a in parallel with the resonant circuit 28. Resonant circuit 28 is preferably the parallel combination of coil or antenna 30 and capacitor 32. Alternatively, a second coil or antenna 30a may be included to act as a separate receive antenna while the antenna 30 acts as the transmit antenna. As yet another alternative, either or both a receive antenna and a transmit antenna may be provided in addition to the resonant circuit 28. The modulator 48 further changes the division factor of the programmable divider 25 to divide the reference carrier by a selectable ratio ( $n_1$ ,  $n_4$ ) to one of two selectable frequencies ( $f_1$ ,  $f_4$ ). The control circuit 16 further controls a switch 50 to change the resonant frequency of resonant circuit 28 by connecting a capacitor 52 in parallel with the resonant circuit 28. When the switch 50 is open and the switch 50a is closed, the resonant circuit 28 oscillates at frequency  $f_1$ . In one embodiment,  $f_1$  and  $f_4$  are chosen to be higher than  $f_2$  and  $f_3$  (see Fig. 4). When switch 50a is opened, the resonant circuit 28 will resonate at the Write frequency  $f_4$ . The closing of switch 50 by control circuit 16 will lower the resonant frequency of the resonant circuit to be between  $f_2$  and  $f_3$  such that the interrogator 12 is operable to receive a response signal from the transponder 14 (Read mode). For receiving the RF response, the power stage or amplifier 26 is normally turned off during the response time period. The value of capacitors 52, 52a may be chosen such that switch 50a will be open or closed during the Read mode.

[0010] Alternatively,  $f_1$  and  $f_4$  may be chosen to be lower than  $f_2$  and  $f_3$  in which case switch 50 will be closed and capacitor 52 connected in parallel to the resonant circuit 28 and switch 50a will be open to yield frequency  $f_1$ . Opening of switch 50 will disconnect capacitor 52 allowing the resonant circuit 28 to resonate at a frequency between  $f_2$  and  $f_3$ . Closing of switch 50a while switch 50 remains closed will allow the resonant circuit 28 to resonate at Write frequency  $f_4$ .

[0011] The interrogator 12 might be a stand alone unit, or alternatively, might be connected by a host connection 18 to a host computer. The control circuit 16 is preferably connected to a memory 20 that is operable to maintain, among other things, a list of instructions for the control circuit 16 to execute, information regarding various transponders 14 and groups of transponders for addressing. The memory 20 is also operable to receive information written to it by control circuit 16. This information may be gained from inquiries of the transponder 14 and may include data and addresses returned by the transponder 14. Yet another component preferably operating under the control of the control circuit 16 is a display 22 that may visually express to a user the results of an interrogation or communicate status information.

[0012] Referring now to Fig. 2, a PWM preferred embodiment is illustrated. In this embodiment, as in the FSK embodiment, generator 24, divider 25 and power stage 26 generate the powering frequency  $f_1$ . In the illustrated PWM embodiment the frequency  $f_1$  is used to represent both logic states of the WRITE using a single frequency as is well known in the art. This frequency,  $f_1$ , is preferably also used as a powering signal during the "charge" phase. The PWM keying

may be accomplished by control circuit 16 controlling power stage or amplifier 26. Because switch 50 is open, the resonant frequency of the resonant circuit 28 stays at  $f_1$ . In one embodiment,  $f_1$  is chosen to be higher than  $f_2$  and  $f_3$  (see Fig. 5). In such an embodiment, the closing of switch 50 will lower the resonant frequency of the resonant circuit to be between  $f_2$  and  $f_3$  and the interrogator 12 is then enabled to receive response signals from the transponder 14. The power stage 26 may be switched off during this Read mode to further minimize potential interference with the response signals.

[0013] Alternatively,  $f_1$  may be chosen to be lower than  $f_2$  and  $f_3$  in which case switch 50 will be closed for the Write mode and capacitor 52 connected in parallel to the resonant circuit 28 to yield frequency  $f_1$ . Opening of switch 50 upon entering the Read mode will allow the resonant circuit 28 to increase its resonance frequency to a frequency between  $f_2$  and  $f_3$ .

[0014] Referring now to Fig. 3, a timing diagram of the preferred embodiment of the present invention is shown. The timing diagram shown here is divided into two phases. The phases used include a "powering" or "charge" phase and a "communication" phase. The "charge" phase lasts for a duration of  $t_0$ . During the "charge" phase the interrogator 10 charges the transponder 12 with a powering burst of frequency  $f_1$ . In the embodiment where the interrogator uses a single antenna 28 for powering and communication, a short "end-of-burst" occurs during which no carrier is transmitted from the interrogator. This short "end-of-burst" is necessary to allow the transponder 12 to differentiate between the "charge" phase and the Write mode of the "communication" phase. The transponder 14 senses the short "end-of-burst" and adjusts its frequency for receiving a signal from the interrogator 12. For FSK frequencies, for example, the frequency of the resonant circuit 34 is lowered to between  $f_1$  and  $f_4$ . For other types of modulation such as PPM or PWM, the transponder 14 may not have to adjust its resonant circuit 34. The transponder 14 may also at this time damp its resonant circuit 34 by connecting a resistor 58 in parallel with resonant circuit 34.

[0015] After the "charge" phase and the Write mode of the "communication" phase, the interrogator 12 transmits a longer "end-of-burst" signal. The longer "end-of-burst" signal serves to indicate that the Read mode is about to begin (whether or not a Write mode was previously entered into). This Read mode can occur with or without a preceding Write mode and is tested for by measuring the duration of the "end-of-burst." The transponder resonant circuit 34 does not change until after a delay period,  $t_1$ . This delay period allows for detection of the "end-of-burst." The duration of this delay period,  $t_1$ , is greater than that of the long "end-of-burst." After the end of the "end-of-burst" the transponder 14 can now respond to the RF interrogation.

[0016] Fig. 4 is a frequency spectrum illustrating the power spectrums for the highly tuned and detuned configurations of the transponder 14 and the interrogator 12 (graphs A, B, C, and D) for the embodiment wherein FSK is used for the Write function. Graph A shows the passband for the relatively high Q-factor configuration of the transponder resonant circuit 28 during the charge function. Graph B shows the passband for the relatively low Q-factor configuration of the transponder resonant circuit 28 during the write function. The impulses shown at  $f_1$  and  $f_4$  show the FSK frequencies sent by the interrogator 12 during the Write function. As can be seen by the figure Graph B encompasses both frequencies  $f_1$  and  $f_4$ . Graph C shows the passband for the interrogator resonant circuit 20,52 (optionally 52a) during its read function. Graph D shows the resulting passband of the filter/demodulator 64 and encompasses the impulses at frequencies  $f_2$  and  $f_3$ , which are the FSK frequencies of the transponder response.

[0017] Fig. 5 is a frequency spectrum illustrating the power spectrums for the highly tuned and detuned configurations of the transponder 14 and the interrogator 12 (graphs A, C, and D) for the embodiment wherein PWM is used for the Write function. Graph A shows the passband for the relatively high Q-factor configuration of the transponder resonant circuit 28 during the charge function. The impulse shown at  $f_1$  shows the frequency sent by the interrogator 12 during the PWM Write function and the powering function. Graph C shows the passband for the interrogator resonant circuit 20,52 during its read function. Graph D shows the resulting passband of the filter/demodulator 64 and encompasses the impulses at frequencies  $f_2$  and  $f_3$ , which are the FSK frequencies of the transponder response.

[0018] As previously mentioned, yet other embodiments could include selecting  $f_1$  and  $f_4$  to be less than  $f_2$  and  $f_3$ . This principle could be applied to either the FSK embodiment or the PWM embodiment. Another embodiment mentioned herein is the PPM embodiment whose structure would be very similar to that for PWM.

[0019] Now that the phases and frequency spectrums have been named and listed and an overview of the main components of the transponder system has been described, the remaining components and their uses during each phase will be described.

[0020] Again referring to Fig. 1, now together with Fig. 3 and Fig. 4, the remaining components, timing, and frequency spectrum of the preferred embodiment will be described. During the "charge" phase, within the interrogator 12 a carrier wave generator 24 operates to provide a reference frequency to a programmable divider 25. A buffer or amplifier 26 receives a divided carrier having a first frequency,  $f_1$ , from the programmable divider 25 and passes the signal to an interrogator tuned circuit 28. Tuned circuit 28 is preferably tuned to  $f_1$  although it is well known that a harmonic of the resonant frequency  $f_1$  or another frequency could be used if design needs so dictate. In this embodiment, the modulator 48 further acts to select the resonant frequency of the tuned circuit 28 to coincide with the corresponding frequency selected by the modulator 48 using the programmable divider 25. The mechanism that modulator 48 and the control

circuit 16 uses to select the resonant frequency of tuned circuit 28 is the combination of switches 50, 50a. The tuned circuit 28 preferably comprises the parallel combination of a coil 30 and a capacitor 32. The switch 50 when closed forms a parallel connection of another capacitor 52 across tuned circuit 28 thus lowering the resonant frequency of resonant circuit 28 to a frequency between  $f_2$  and  $f_3$ . A series resonant circuit could also be used as tuned circuit 28 if the amp 26 is to drive a low impedance tuned circuit (e.g., a series resonant circuit). The oscillation of this tuned circuit 28 transmits RF energy, which is received by the transponder 14. A transponder resonant circuit 34 that also is tuned ideally to  $f_1$  receives this energy. The transponder resonant circuit 34 preferably comprises the parallel combination of a coil 36 and a capacitor 38. A transponder control circuit 40 is connected to this resonant circuit 34 at a reference connection 42 and at a signal connection 44. The control circuit 40 receives its energy from the resonant circuit 34, rectifies the received signals, and stores the energy on a storage capacitor 46. The mechanisms for rectifying signals and storing energy are well known to one of ordinary skill in the art. Examples of circuitry for performing these functions can be found in Josef H. Schuermann's U.S. Patent No. 5,053,774, assigned to Texas Instruments.

[0021] As shown in Fig. 3, the "charge" phase is succeeded by the "communication" phase. After the interrogator 12 sends a short "end-of-burst" during which no RF energy is transmitted therefrom, the transponder 14 detects this short "end-of-burst" and dampens the resonant circuit 34. Transponder 14 further increases the frequency of resonant circuit 34 to a frequency between  $f_1$  and  $f_4$  by disconnecting a capacitor 56 and connecting a resistor 58 in parallel with the resonant circuit 34. The transponder 14 is now prepared to receive WRITE data from the interrogator 12.

[0022] During the write function of the "communication" phase the control circuit 16 sends data to a modulator 48. An FSK modulator 48 under direction of control circuit 16 operates to control programmable frequency divider 25 to pass either a first frequency,  $f_1$ , or a second frequency,  $f_4$ , on to buffer/amplifier 26. The frequencies  $f_1$  and  $f_4$  are selected submultiples of the reference frequency. The carrier wave generator 24 is preferably a crystal oscillator. As an example, one polarity of the WRITE data might be the reference carrier divided by ratio  $n_1$  ( $f_1$ ), while the other polarity of the WRITE data might be represented by another frequency that is the reference carrier divided by ratio  $n_4$  ( $f_4$ ). The modulator 48 controls a switch 50a that can connect a capacitor 52 in parallel with tuned circuit 28. Control circuit 16 controls a switch 50 that can connect a capacitor 52 in parallel with tuned circuit 28.

[0023] Disconnecting the capacitor 52 from the tuned circuit 28 forms a new tuned circuit 29 with a new, higher resonant frequency  $f_4$ . By opening and closing switch 50a in synchronism with the control of programmable divider 25 the resonant circuit 28 or new resonant circuit 29 remains optimally tuned to the transmitted frequency  $f_1$  or  $f_4$ . By choosing  $f_1$  to represent one logic level and  $f_4$  to represent another it is possible to transmit information from the interrogator 12 to the transponder 14. Data is received in the transponder 14 by the transponder's resonant circuit 34. A downlink signal is passed on to demodulator 66 that in turn transmits a received data stream to the control circuit 40. The received WRITE data is typically FSK demodulated by the demodulator 66. Techniques and circuits for FSK demodulation are well known in the art.

[0024] After the "charge" phase and the Write mode of the "communication" phase, the interrogator 12 transmits a longer "end-of-burst" signal. The longer "end-of-burst" signal serves to indicate that the Read mode is about to begin (whether or not a Write mode was entered into). This Read mode can occur with or without a preceding Write mode and is tested by measuring the duration of the "end-of-burst." The transponder resonant circuit 34 does not change until after a delay period,  $t_1$ . This delay period, which begins concurrently with the "end-of-burst," but is defined to be slightly longer in duration allows for detection of the "end-of-burst." After the end of the "end-of-burst" the transponder 14 can now respond to the RF interrogation. During the delay period,  $t_1$ , and during the Read mode the interrogator resonant circuit 28 may be damped by connecting a resistor 51 in parallel with the resonant circuit 28. This connection may be accomplished by providing a switch 49 under direction of control circuit 16 serially between the resistor 51 and ground.

[0025] A frequency spectrum of a first preferred embodiment is shown in Fig. 4. Graph A shows the frequency response of the resonant circuits 28, 34. Because these resonant circuits 28, 34 have a high Q, the graph has a very narrow base and a high peak. Graph B shows the effect on resonant circuit 34 in closing switch 54 and opening switch 54a to form new resonant circuit 60. Graph B is centered between  $f_1$  and  $f_4$  and has a broad base which does have a significant frequency response at both  $f_1$  and  $f_4$ . Because the resonant circuits 28, 60 are no longer tightly coupled during the "communication" phase, the energy transmission from the interrogator 12 to the transponder 14 is reduced. Thus, the storage capacitor 46 supplies energy to the transponder circuitry for the transponder 14 to remain operational.

[0026] Again referring to Fig. 1, during READ function the interrogator tuned circuit 28 is damped to enable downlink FSK reception. The interrogator tuned circuit 28 might be damped by the control circuit 16 by disabling the carrier wave generator 24 and by shunting a switch/resistor series 49, 51 combination across the resonant circuit. This damping of the carrier wave generator 24 is described in the '774 patent by Schuermann et al. Once the oscillation of resonant circuit 28 is damped, the interrogator 12 is free to receive signals from the transponder 14. Within the transponder 14, the resonant circuit 34 continues to oscillate until the energy stored therein is dissipated. The transponder 14 can now respond to the interrogator 12 by using a switch 70 to connect capacitor 72 and switch 70a to connect capacitor 72a across the resonant circuit 34. Now in the transponder's 14 response to the interrogator 12 READ data is represented upon the uplink signal by a first frequency,  $f_2$ , that might be the resonant frequency,  $f_2$  of capacitor 72a in parallel with

resonant circuit 34 and by a second frequency,  $f_3$ , which might be the resonant frequency of capacitor 72 and capacitor 72a in parallel with resonant circuit 34. Thus, the first frequency might represent the transmission from the transponder to the interrogator of a digital ONE or the high-bit frequency and the second frequency might represent the transmission of a digital ZERO or the low-bit frequency. This uplink is then demodulated by the interrogator demodulator 64 and supplied to control circuit 16 that may store the data in memory 20, transmit the data to a host via the connection 18, or display status information or data to an operator on a display 22.

[0027] Because the power transmission frequency,  $f_1$ , and the write frequencies  $f_2$  and  $f_4$ , are out of the passband of the interrogator receive circuit, other active interrogators 12 do not interfere with the receiving in said interrogator 12 of RF responses from the transponder 14.

[0028] In some embodiments upon receipt and demodulation of the downlink signal the control circuit 40 writes to memory 62. In yet another embodiment, a separate receive circuit can be provided in the interrogator 12. In such an embodiment, switches 49 and 50 are no longer needed, nor are the capacitor 52 or the resistor 51. The resonant frequency of the receive circuit can be selected to be above or below the frequency of the powering burst  $f_1$  depending upon the application and the transponders 14 used with the interrogator 12.

[0029] With reference now to Fig. 2, now together with Fig. 3 and Fig. 5, the system using PWM for the Write function will be described. This embodiment is substantially similar to the FSK embodiment. The differences from Fig. 1 are shown in Fig. 2. Particularly, in this embodiment the control circuit 16 further acts to select the resonant frequency of the tuned circuit 28 whereas in the FSK embodiment the modulator 48 performed this function, although the control circuit 16 could have also performed this function in the FSK embodiment. Since in this embodiment, a single frequency is used for the Write function modulation, only a single switch 50 need be controlled by the control circuit 16. Switch 50 is used to select between the powering/Write frequency  $f_1$  and the center of the Read frequencies,  $f_2$  and  $f_3$ . As is the characteristic for PWM demodulation, the demodulator 66 is able to demodulate the WRITE data from the interrogator 12 by measuring the length of the periods in which no RF energy is being sent. During these switch off phases, the control circuit 16 disables the amplifier 26 so that no RF energy is output from the interrogator 12. An exemplary PWM format would be for a high bit to be represented by a switch off period of a relatively longer time than for a low bit. For example, one polarity of the WRITE data might be represented by a switch off period of 1 ms, while the other polarity might be represented by a period of 0.3 ms. Thus it is possible to transmit information from the interrogator 12 to the transponder 14.

[0030] The sole table, below, provides an overview of the embodiments and the drawings:

TABLE

Drawing Element	Generic Term	Preferred or Specific Term	Alternate Terms
10	Transponder Arrangement		
12	Interrogator	Interrogator	Reader
14	Transponder	Transponder	Responder, Tag
16	Control Circuit	Interrogator Control Circuit	
18	Connection	Host Computer Connection	
20	Memory	Interrogator Memory	SRAM, DRAM, EEPROM
22	Display		LCD, CRT, LED display, VF display
24	Carrier Wave Generator	Carrier Wave Generator	Oscillator, Crystal Oscillator
26	Buffer	Buffer/Amplifier	
28	Resonant Circuit	Interrogator $f_1$ Resonant Circuit	Antenna
30	Coil		
32	Capacitor		
34	Resonant Circuit	Transponder $f_1$ Resonant Circuit	Antenna
36	Coil		
38	Capacitor		

TABLE (continued)

Drawing Element	Generic Term	Preferred or Specific Term	Alternate Terms
40	Control Circuit	Transponder Control Circuit	Microprocessor, Microcontroller
42	Reference Line	Reference Voltage	Reference Voltage Connection
44	Signal Line	Signal Line	Reference Signal Connection
46	Energy Storage Device	Storage Capacitor	Rechargeable Battery
48	Modulator	FSK Modulator	
49	Switch	Damping Switch	
50,50a	Switch		
51	Resistor	Damping Resistor	
52,52a	Resonant Circuit	Interrogator $f_2$ Resonant Circuit	
54	Switch		
56	Capacitor		
58	Damping Element	Resistor	
60	Resonant Circuit	Transponder $f_3$ Resonant Circuit	
62	Memory	Transponder Memory	EEPROM, SRAM, ROM
64	Demodulator	Interrogator Filter/Demodulator	
66	Demodulator	FSK Demodulator	PLL FSK Demodulator
70	Switch	Transponder Modulator Switch	
72	Capacitor	Transponder Modulator Capacitor	

[0031] A few preferred embodiments have been described in detail hereinabove. It is to be understood that the scope of the invention also comprehends embodiments different from those described, yet within the scope of the claims.

[0032] For example, "microcomputer" is used in some contexts to mean that microcomputer requires a memory and "microprocessor" does not. The usage herein is that these terms can also be synonymous and refer to equivalent things. The phrase "processing circuitry" or "control circuitry" comprehends ASICs (application specific integrated circuits), PAL (programmable array logic), PLAs (programmable logic arrays), decoders, memories, non-software based processors, or other circuitry, or digital computers including microprocessors and microcomputers of any architecture, or combinations thereof. Memory devices include SRAM (static random access memory), DRAM (dynamic random access memory), pseudo-static RAM, latches, EEPROM (electrically-erasable programmable read-only memory), EPROM (erasable programmable read-only memory), registers, or any other memory device known in the art. Words of inclusion are to be interpreted as nonexhaustive in considering the scope of the invention.

[0033] Frequency shift keying (FSK) modulation is envisioned as a possible data modulation scheme, as well as pulse-pause modulation, amplitude shift keying (ASK), quadrature AM (QAM) modulation, quadrature phase shift keying (QPSK), or any other modulation. Different types of multiplexing such as time or frequency modulation might be effected to avoid cross-signal interference. Implementation is contemplated in discrete components or fully integrated circuits in silicon, gallium arsenide, or other electronic materials families, as well as in optical-based or other technology-based forms and embodiments. It should be understood that various embodiments of the invention can employ or be embodied in hardware, software or microcoded firmware.

#### Claims

1. A Radio Frequency Identification (RFID) system, said system comprising:

a) an interrogator (12), said interrogator (12) having

i) a carrier wave generator (24) for generating a powering burst of powering frequency,  
 ii) a demodulator (64) for demodulating response data from an RF response from a transponder (14), said RF response being a wireless, modulated carrier signal,  
 iii) a tuned circuit (28) in electrical communication with said demodulator (64),  
 iv) a controller (16) in electrical communication with said tuned circuit (28) and said demodulator (64), said controller (16) operable to enable said carrier wave generator (24) to send said powering burst during a first time period and to enable said demodulator (64) in electrical communication with said tuned circuit (28) to receive said RF response during a second time period; and

b) a transponder (14), said transponder (14) having:

i) a tuned circuit (34) operable to oscillate with a carrier having a frequency equal to the resonance frequency of said tuned circuit (34),  
 ii) a tuning circuit (70, 72, 70a, 72a) in electrical communication with said tuned circuit (34) for modifying the frequency characteristics of said tuned circuit (34) and  
 iii) a modulator in electrical communication with said tuned circuit (34) for modulating the carrier therein with RF response data to form said RF response;  
 said system characterized in that it comprises more than one interrogator, that said interrogator tuned circuit has a selected bandwidth about a communication frequency, said selected bandwidth not substantially overlapping said powering frequency and encompassing the bandwidth of the modulated carrier of said RF response such that said powering burst of one interrogator does not interfere with the reception, by another interrogator, of said RF response, and that said transponder tuning circuit (70, 72, 70a, 72a) modifies the frequency characteristics of said transponder tuned circuit (34) such that the tuned circuit (34) is operable to be tuned during said powering burst to said powering frequency and to be tuned during said RF response to said communication frequency, said powering signal causing the tuned circuit (34) to oscillate with a carrier having said powering frequency.

2. The system of claim 1, wherein said interrogator tuned circuit (28) comprises another tuning circuit (50, 52) whereby said another tuning circuit (50, 52) is operable to modify the frequency characteristics of said tuned circuit (28) such that said tuned circuit (28) is tuned during said powering burst to said powering frequency and tuned during said RF interrogation to said communication frequency.

3. The system of claim 1 or claim 2, wherein said modulator is a PPM modulator.

4. The system of claim 1 or claim 2, wherein said modulator is a FSK modulator operable to output a carrier of FSK frequencies  $f_2$  and  $f_3$  representing first and second data values.

5. The system of claim 4, wherein said communication frequency is between said FSK frequencies.

6. The system of any preceding claim and further comprising an interrogator modulator (48) for modulating WRITE data upon said RF interrogation.

7. The system of claim 6, wherein said interrogators further comprise a transmit antenna (30) in electrical communication with said interrogator modulator (48) and operable to transmit said RF interrogation in a wireless fashion, and a receive antenna (30a) in electrical communication with said demodulator (64) and operable to receive said RF response from said transponder (14) in a wireless fashion.

8. The system of claim 7, wherein said transmit antenna and said receive antenna are a single, unified antenna (30).

9. A Radio Frequency Identification (RFID) System, as claimed in any preceding claim and wherein:

a) said interrogators comprise

i) an RF oscillator (24),  
 ii) a programmable divider (25) in electrical communication with said RF oscillator (24) and operable to selectively divide the oscillations such that a first division factor causes a communication frequency signal to be output from said divider (25) and a second division factor causes a powering frequency signal to be

output from said divider (25),

iii) a first tuned circuit (28) in electrical communication with said programmable divider (25), said first tuned circuit (28) having a resonant frequency of said powering frequency, said first tuned circuit (28) operable to send a powering burst,

iv) a second tuned circuit (29) in electrical communication with said programmable divider (25), said second tuned circuit (29) having a selected bandwidth encompassing an RF response about said communication frequency, said selected bandwidth not substantially overlapping said powering frequency such that said powering burst of one interrogator does not interfere with the reception, by another interrogator, of said RF response.

10. A system as claimed in claim 9 and including a transmit antenna in electrical communication with said first tuned circuit (28) and operable to transmit said powering burst as a wireless signal to said transponder (14) and to transmit said RF interrogation thereto.

11. A system as claimed in claim 9 or claim 10 and including a receive antenna in electrical communication with said second tuned circuit (29), said receive antenna operable to receive said RF response.

12. A system as claimed in any preceding claim and wherein said transponder (14) includes a demodulator (66) in electrical communication with said tuned circuit (34) for receiving said RF interrogation therefrom and for demodulating interrogation data from said RF interrogation.

13. A system as claimed in claim 12 and wherein said transponder (14) includes a controller (40) in electrical communication with said modulator, said demodulator (66) and said tuning circuit (70, 72, 70a, 72a), said controller (40) operable to control said tuning circuit (70, 72, 70a, 72a) to modify the frequency characteristics of said tuned circuit (34), to receive said interrogation data from said demodulator (66) and to provide said RF response data to said modulator.

14. A method for communicating between more than one interrogator (12) and a transponder (14), the method comprising the steps of:

- a) tuning a transponder tuned circuit (34) to a powering frequency;
- b) sending a powering burst of said powering frequency to said transponder (14) by an interrogator tuned circuit (28), said powering burst causing said tuned circuit (34) to oscillate with a carrier having said powering frequency;
- c) rectifying said powering burst in said transponder (14) to supply power to the operating circuitry thereof;
- d) upon termination of said powering burst, tuning said transponder (14) to having a communication frequency whereby the oscillation of said carrier will be at said communication frequency, further selecting the bandwidth of said tuned circuit (34) to be a selected width and not substantially encompassing said power frequency, such that said powering burst of one interrogator does not interfere with the reception, by another interrogator, of said RF response;
- e) entering a Read mode during which a modulator modulates data upon said carrier to form an RF response, said RF response having a bandwidth such that a substantial portion thereof lies within the bandwidth of said tuned circuit (34);
- f) transmitting said RF response by said tuned circuit (34) in electrical communication with said modulator; and
- g) receiving by a receiver circuit said RF response.

15. The method of claim 14 and further comprising the step of sending an "end-of-burst" signal after completion of said powering burst and prior to entering said Read mode.

16. The method of claim 14 or claim 15 and further comprising the step of entering a Write mode prior to entering the Read mode during which the interrogator sends WRITE data to said transponder (14) upon termination of said powering burst.

17. The method of claim 16 and further comprising the step of sending a short "end-of-burst" signal after completion of said powering burst and prior to entering said Write mode.

18. The method of claim 17 and further comprising the step of sending a long "end-of-burst" after completion of said Write mode and prior to entering said Read mode.

19. The method of any of claims 14 to 18 and further comprising the step of sending an "end-of-burst" signal after completion of said powering burst.

# Patentansprüche

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1. Funkfrequenz-Identifizierungssystem (HFID-System), wobei das System umfaßt:

a) eine Abfragevorrichtung (12), die enthält:

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- i) einen Trägerwellengenerator (24) zum Erzeugen eines Speise-Bursts und einer Speisefrequenz,
- ii) einen Demodulator (64) zum Demodulieren von Antwortdaten von einer HF-Antwort von einem Transponder (14), wobei die HF-Antwort ein modulierte Funk-Trägersignal ist,
- iii) eine abgestimmte Schaltung (28), die mit dem Demodulator (64) in einer elektrischen Verbindung steht,
- iv) einen Controller (16), der mit der abgestimmten Schaltung (28) und mit dem Demodulator (64) in einer elektrischen Verbindung steht, wobei der Controller (16) so betreibbar ist, daß der Trägerwellengenerator (24) den Speise-Burst während einer ersten Zeitperiode senden kann und der Demodulator (64), der mit der abgestimmten Schaltung (28) in elektrischer Verbindung steht, die HF-Antwort während einer zweiten Zeitperiode empfangen kann; und

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b) einen Transponder (14), der enthält:

- i) eine abgestimmte Schaltung (34), die so betreibbar ist, daß sie mit einem Träger oszilliert, der eine Frequenz besitzt, die gleich der Resonanzfrequenz der abgestimmten Schaltung (34) ist,
  - ii) eine Abstimmungsschaltung (70, 72, 70a, 72a), die mit der abgestimmten Schaltung (34) in elektrischer Verbindung steht, um die Frequenzcharakteristik der abgestimmten Schaltung (34) zu modifizieren, und
  - iii) einen Modulator, der mit der abgestimmten Schaltung (34) in elektrischer Verbindung steht, um den Träger darin mit den HF-Antwortdaten zu modulieren, um die HF-Antwort zu bilden;
- wobei das System dadurch gekennzeichnet ist, daß es mehr als eine Abfragevorrichtung enthält, daß die abgestimmte Schaltung der Abfragevorrichtung eine ausgewählte Bandbreite um eine Kommunikationsfrequenz besitzt, wobei die ausgewählte Bandbreite nicht wesentlich mit der Speisefrequenz überlappt und die Bandbreite des modulierten Trägers der HF-Antwort umschließt, so daß der Speise-Burst einer Abfragevorrichtung nicht den Empfang der HF-Antwort durch eine weitere Abfragevorrichtung stört, und daß
- die Transponder-Abstimmungsschaltung (70, 72, 70a, 72a) die Frequenzcharakteristik der abgestimmten Schaltung (34) des Transponders modifiziert, so daß die abgestimmte Schaltung (34) so betreibbar ist, daß sie während des Speise-Bursts auf die Speisefrequenz abgestimmt ist und während der HF-Antwort auf die Kommunikationsfrequenz abgestimmt ist, wobei das Speisesignal die abgestimmte Schaltung (34) dazu veranlaßt, mit einem Träger mit der Speisefrequenz zu oszillieren.

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2. System nach Anspruch 1, wobei die abgestimmte Schaltung (28) der Abfragevorrichtung eine weitere Abstimmungsschaltung (50, 52) enthält, wobei die weitere Abstimmungsschaltung (50, 52) so betreibbar ist, daß sie die Frequenzcharakteristik der abgestimmten Schaltung (28) in der Weise modifiziert, daß die abgestimmte Schaltung (28) während des Speise-Bursts auf die Speisefrequenz abgestimmt ist und während der HF-Abfrage auf die Kommunikationsfrequenz abgestimmt ist.

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3. System nach Anspruch 1 oder Anspruch 2, wobei der Modulator ein PPM-Modulator ist.

4. System nach Anspruch 1 oder Anspruch 2, wobei der Modulator ein FSK-Modulator ist, der so betreibbar ist, daß er einen Träger mit FSK-Frequenzen  $f_2$  und  $f_3$  ausgibt, die erste und zweite Datenwerte repräsentieren.

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5. System nach Anspruch 4, wobei die Kommunikationsfrequenz zwischen den FSK-Frequenzen liegt.

6. System nach irgendeinem vorangehenden Anspruch, ferner mit einem Abfragevorrichtungsmodulator (48) zum Modulieren von SCHREIB-Daten aufgrund der HF-Abfrage.

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7. System nach Anspruch 6, wobei die Abfragevorrichtungen ferner eine Sendeantenne (30), die mit dem Abfragevorrichtungsmodulator (48) in elektrischer Verbindung steht und so betreibbar ist, daß sie die HF-Abfrage per Funk sendet, sowie eine Empfangsantenne (30a), die mit dem Demodulator (64) in elektrischer Verbindung steht und so

betreibbar ist, daß sie die HF-Antwort vom Transponder (14) per Funk empfängt, umfassen.

8. System nach Anspruch 7, wobei die Sendeantenne und die Empfangsantenne eine einzige, vereinheitlichte Antenne (30) bilden.

9. Funkfrequenz-Identifizierungssystem (HFID-System) nach einem vorangehenden Anspruch, wobei

a) die Abfragevorrichtungen umfassen:

i) einen HF-Oszillator (24),

ii) einen programmierbaren Teiler (25), der mit dem HF-Oszillator (24) in elektrischer Verbindung steht und so betreibbar ist, daß er die Oszillationen wahlweise unterteilt, so daß ein erster Unterteilungsfaktor bewirkt, daß ein Kommunikationsfrequenzsignal vom Teiler (25) ausgegeben wird, und ein zweiter Unterteilungsfaktor bewirkt, daß ein Speisefrequenzsignal vom Teiler (25) ausgegeben wird,

iii) eine erste abgestimmte Schaltung (28), die mit dem programmierbaren Teiler (25) in elektrischer Verbindung steht, wobei die erste abgestimmte Schaltung (28) eine Resonanzfrequenz der Speisefrequenz besitzt, wobei die erste abgestimmte Schaltung (28) so betreibbar ist, daß sie einen Speise-Burst sendet,

iv) eine zweite abgestimmte Schaltung (29), die mit dem programmierbaren Teiler (25) in elektrischer Verbindung steht, wobei die zweite abgestimmte Schaltung (29) eine ausgewählte Bandbreite besitzt, die eine HF-Antwort um die Kommunikationsfrequenz umschließt, wobei die ausgewählte Bandbreite mit der Speisefrequenz nicht wesentlich überlappt, so daß der Speise-Burst einer Abfragevorrichtung den Empfang der HF-Antwort durch eine weitere Abfragevorrichtung nicht stört.

10. System nach Anspruch 9, mit einer Sendeantenne, die mit der ersten abgestimmten Schaltung (28) in elektrischer Verbindung steht und so betreibbar ist, daß sie den Speise-Burst als Funksignal an den Transponder (14) sendet und die HF-Abfrage an ihn sendet.

11. System nach Anspruch 9 oder Anspruch 10, mit einer Empfangsantenne, die mit der zweiten abgestimmten Schaltung (29) in elektrischer Verbindung steht, wobei die Empfangsantenne so betreibbar ist, daß sie die HF-Antwort empfängt.

12. System nach einem vorangehenden Anspruch, wobei der Transponder (14) einen Demodulator (66) enthält, der mit der abgestimmten Schaltung (34) in elektrischer Verbindung steht, um die HF-Abfrage hiervon zu empfangen und um Abfragedaten von der HF-Abfrage zu demodulieren.

13. System nach Anspruch 12, wobei der Transponder (14) einen Controller (40) enthält, der mit dem Modulator, dem Demodulator und der Abstimmungsschaltung (70, 72, 70a, 72a) in elektrischer Verbindung steht, wobei der Controller (40) so betreibbar ist, daß er die Abstimmungsschaltung (70, 72, 70a, 72a) steuert, um die Frequenzcharakteristik der abgestimmten Schaltung (34) zu modifizieren, die Abfragedaten vom Demodulator (66) zu empfangen und die HF-Antwortdaten für den Modulator bereitzustellen.

14. Verfahren für die Kommunikation zwischen mehr als einer Abfragevorrichtung (12) und einem Transponder (14), wobei das Verfahren die folgenden Schritte umfaßt:

a) Abstimmen einer abgestimmten Schaltung (34) des Transponders auf eine Speisefrequenz;

b) Senden eines Speise-Bursts der Speisefrequenz an den Transponder (14) durch eine abgestimmte Schaltung (28) einer Abfragevorrichtung, wobei der Speise-Burst die abgestimmte Schaltung (34) dazu veranlaßt, mit einem Träger mit der Speisefrequenz zu oszillieren;

c) Gleichrichten des Speise-Bursts im Transponder (14), um Leistung an die Betriebsschaltung hiervon zu liefern;

d) nach dem Ende des Speise-Bursts Abstimmen des Transponders (14), so daß er eine Kommunikationsfrequenz besitzt, wobei die Oszillation des Trägers mit der Kommunikationsfrequenz erfolgt, ferner Auswählen der Bandbreite der abgestimmten Schaltung (34), so daß sie eine ausgewählte Breite ist und die Speisefrequenz im wesentlichen nicht umschließt, so daß der Speise-Burst einer Abfragevorrichtung nicht den Empfang der HF-Antwort durch eine weitere Abfragevorrichtung stört;

e) Eingeben eines Lese-Modus, währenddessen ein Modulator Daten auf den Träger moduliert, um eine HF-Antwort zu bilden, wobei die HF-Antwort eine Bandbreite besitzt, derart, daß ein wesentlicher Teil hiervon innerhalb der Bandbreite der abgestimmten Schaltung (34) liegt;

- f) Senden der HF-Antwort durch die abgestimmte Schaltung (34), die mit dem Modulator in elektrischer Verbindung steht; und
- g) Empfangen der HF-Antwort durch eine Empfängerschaltung.

- 5 15. Verfahren nach Anspruch 14, ferner mit dem Schritt des Sendens eines "Burstende"-Signals nach Abschluß des Speise-Bursts und vor dem Eintritt in den Lesemodus.
- 16. Verfahren nach Anspruch 14 oder Anspruch 15, ferner mit dem Schritt des Eintretens in einen Schreibmodus vor dem Eintreten in den Lesemodus, währenddessen die Abfragevorrichtung nach dem Ende des Speise-Bursts  
10 SCHREIB-Daten an den Transponder (14) sendet.
- 17. Verfahren nach Anspruch 16, ferner mit dem Schritt des Sendens eines kurzen "Burstende"-Signals nach dem Ende des Speise-Bursts und vor dem Eintritt in den Schreibmodus.
- 15 18. Verfahren nach Anspruch 17, ferner mit dem Schritt des Sendens eines langen "Burstendes" nach Abschluß des Schreibmodus und vor dem Eintritt in den Lesemodus.
- 19. Verfahren nach einem der Ansprüche 14 bis 18, ferner mit dem Schritt des Sendens eines "Burstende"-Signals nach dem Ende des Speise-Bursts.

## Revendications

1. Système d'identification à fréquence radio (RFID), ledit système comprenant :

a) un interrogateur (12), ledit interrogateur (12) comportant

- i) un générateur d'onde porteuse (24) pour produire une salve d'alimentation ayant une fréquence d'alimentation,
- ii) un démodulateur (64) pour démoduler des données de réponse provenant d'une réponse RF délivrée par un transpondeur (14), ladite réponse RF étant un signal de porteuse modulée sans fil,
- 30 iii) un circuit accordé (28) en communication électrique avec ledit démodulateur (64),
- iv) un contrôleur (16) en communication électrique avec ledit circuit accordé (28) et ledit démodulateur (64), ledit contrôleur (16) pouvant agir de manière à autoriser ledit générateur d'onde porteuse (24) à émettre ladite salve d'alimentation pendant un premier intervalle de temps et à permettre audit démodulateur (64) en communication électrique avec ledit circuit accordé (28) de recevoir ladite réponse RF pendant un second intervalle de temps, et

b) un transpondeur (14), ledit transpondeur (14) possédant :

- 40 i) un circuit accordé (34) pouvant agir de manière à osciller avec une porteuse ayant une fréquence égale à la fréquence de résonance dudit circuit accordé (34),
- ii) un circuit d'accord (70,72,70a,72a) en communication électrique avec ledit circuit accordé (34) pour modifier la caractéristique de fréquence dudit circuit accordé (34); et
- iii) un modulateur en communication électrique avec ledit circuit accordé (34) pour moduler la porteuse avec des données de réponse RF pour former ladite réponse RF;
- 45 ledit système étant caractérisé en ce qu'il comprend plus d'un interrogateur, que ledit circuit accordé d'interrogateur possède une largeur de bande sélectionnée autour d'une fréquence de communication, ladite largeur de bande sélectionnée n'étant essentiellement pas en chevauchement avec ladite fréquence d'alimentation et englobant la largeur de bande de la porteuse modulée de ladite réponse RF de telle sorte que ladite salve d'alimentation d'un interrogateur n'interfère pas avec la réception, par un autre interrogateur, de ladite réponse RF, et que
- 50 ledit circuit d'accord (70,72,70a,72a) du transpondeur modifie la caractéristique de fréquence dudit circuit accordé (34) du transpondeur de telle sorte que le circuit accordé (34) peut agir de manière à être accordé pendant ladite salve d'alimentation à ladite fréquence d'alimentation et de manière à être accordé pendant ladite réponse RF à ladite fréquence de communication, ledit signal d'alimentation amenant le circuit accordé (34) à osciller avec une porteuse possédant ladite fréquence d'alimentation.

2. Système selon la revendication 1, dans lequel ledit circuit accordé (28) de l'interrogateur comprend un autre circuit

d'accord (50,52), ce qui a pour effet que ledit autre circuit d'accord (50,52) peut agir de manière à modifier la caractéristique de fréquence dudit circuit accordé (28) de telle sorte que ledit circuit accordé (28) est accordé pendant ladite salve d'alimentation à ladite fréquence d'alimentation et est accordé pendant ladite interrogation RF à ladite fréquence de communication.

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3. Système selon la revendication 1 ou la revendication 2, dans lequel ledit modulateur est un modulateur PPM.

4. Système selon la revendication 1 ou la revendication 2, dans lequel ledit modulateur est un modulateur FSK pouvant agir de manière à délivrer une porteuse ayant les fréquences FSK  $f_2$  et  $f_3$  représentant les première et seconde valeurs de données.

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5. Système selon la revendication 4, dans lequel ladite fréquence de communication est comprise entre lesdites fréquences FSK.

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6. Système selon l'une quelconque des revendications précédentes et comprenant en outre un modulateur (48) de l'interrogateur, servant à moduler des données d'ECRITURE lors de ladite interrogation RF.

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7. Système selon la revendication 6, dans lequel lesdits interrogateurs comprennent en outre une antenne d'émission (30) en communication électrique avec ledit modulateur (48) de l'interrogateur et pouvant agir de manière à transmettre ladite interrogation RF selon un mode sans fil, et une antenne de réception (30a) en communication électrique avec ledit démodulateur (64) et pouvant agir de manière à recevoir ladite réponse RF de la part dudit transpondeur (14) selon un mode sans fil.

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8. Système selon la revendication 7, dans lequel ladite antenne d'émission et ladite antenne de réception sont une seule antenne unifiée (30).

9. Système d'identification à fréquence radio (RFID) selon l'une quelconque des revendications précédentes, et dans lequel:

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a) lesdits interrogateurs comprennent

i) un oscillateur RF (24),

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ii) un diviseur programmable (25) en communication électrique avec ledit oscillateur RF (24) et pouvant agir de manière à diviser sélectivement les oscillations de telle sorte qu'un premier facteur de division provoque la délivrance d'un signal de fréquence de communication par ledit diviseur (25) et qu'un second facteur de division provoque la délivrance d'un signal de fréquence d'alimentation par ledit diviseur (25),

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iii) un premier circuit accordé (28) en communication électrique avec ledit diviseur programmable (25), ledit premier circuit accordé (28) possédant une fréquence de résonance de ladite fréquence d'alimentation, ledit premier circuit accordé (28) pouvant agir de manière à émettre une salve d'alimentation,

iv) un second circuit accordé (29) en communication électrique avec ledit diviseur programmable (25), ledit second circuit accordé (29) possédant une largeur de bande sélectionnée englobant une réponse RF autour de ladite fréquence de communication, ladite largeur de bande sélectionnée n'étant pas sensiblement en chevauchement avec ladite fréquence d'alimentation de telle sorte que ladite salve d'alimentation d'un interrogateur n'interfère pas avec la réception, par un autre interrogateur, de ladite réponse RF.

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10. Système selon la revendication 9, et comprenant une antenne d'émission en communication électrique avec ledit premier circuit accordé (28) et pouvant agir de manière à émettre ladite salve d'alimentation en tant que signal sans fil en direction dudit transpondeur (14) et pour transmettre ladite interrogation RF à ce transpondeur.

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11. Système selon la revendication 9 ou la revendication 10, et comprenant une antenne de réception en communication électrique avec ledit second circuit accordé (29), ladite antenne de réception pouvant agir de manière à recevoir ladite réponse RF.

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12. Système selon l'une quelconque des revendications précédentes et dans lequel ledit transpondeur (14) comprend un démodulateur (66) en communication électrique avec ledit circuit accordé (34) pour recevoir ladite interrogation RF à partir de ce circuit et pour démoduler des données d'interrogation provenant de ladite interrogation RF.

13. Système selon la revendication 12, et dans lequel ledit transpondeur (14) inclut un contrôleur (40) en communica-

tion électrique avec ledit modulateur, ledit démodulateur (56) et ledit circuit d'accord (70,72,70a, 72a), ledit contrôleur (40) pouvant agir de manière à commander ledit circuit d'accord (70,72,70a,72a) pour modifier la caractéristique de fréquence dudit circuit accordé (34), pour recevoir lesdites données d'interrogation provenant dudit démodulateur (66) et pour délivrer lesdites données de réponse RF audit modulateur.

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14. Procédé de communication entre plus d'un interrogateur (12) et d'un transpondeur (14), le procédé comprenant les étapes consistant à:

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- a) accorder un circuit accordé (34) de transpondeur sur une fréquence d'alimentation;
- b) envoyer une salve d'alimentation de ladite fréquence d'alimentation audit transpondeur (14) par un circuit accordé (28) de l'interrogateur, ladite salve d'alimentation amenant ledit circuit accordé (34) à osciller avec une porteuse possédant ladite fréquence d'alimentation;
- c) redresser ladite salve d'alimentation dans ledit transpondeur (14) pour appliquer une énergie au circuit de fonctionnement de ce transpondeur;
- d) à la fin de ladite salve d'alimentation, accorder ledit transpondeur (14) pour qu'il possède une fréquence de communication, ce qui a pour effet que l'oscillation de ladite porteuse possède ladite fréquence de communication, sélectionner en outre la largeur de bande dudit circuit accordé (34) pour qu'elle soit égale à une largeur sélectionnée et n'englobant pas pour l'essentiel ladite fréquence d'alimentation, de telle sorte que ladite salve d'alimentation d'un interrogateur n'interfère pas avec la réception, par un autre interrogateur, de ladite réponse RF;
- e) passer à un mode de lecture pendant lequel un modulateur module ladite porteuse avec des données de manière à former une réponse RF, ladite réponse RF possédant une largeur de bande telle qu'une partie substantielle de cette largeur de bande se situe à l'intérieur de la largeur de bande dudit circuit accordé (34);
- f) émettre ladite réponse RF au moyen dudit circuit accordé (34) en communication électrique avec ledit modulateur; et
- g) recevoir ladite réponse RF, par un circuit récepteur.

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15. Procédé selon la revendication 14 et comprenant en outre l'étape consistant à envoyer un signal "fin de salve" après achèvement de ladite salve d'alimentation et avant le passage audit mode de lecture.

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16. Procédé selon la revendication 14 ou la revendication 15 et comprenant en outre l'étape consistant à passer, avant de passer au mode de lecture, à un mode d'écriture, pendant lequel l'interrogateur envoie des données d'ECRI-  
TURE audit transpondeur (14) à la fin de ladite salve d'alimentation.

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17. Procédé selon la revendication 16 et comportant en outre l'étape d'envoi d'un court signal "fin de salve" après l'achèvement de ladite salve d'alimentation et avant le passage audit mode d'écriture.

18. Procédé selon la revendication 17 et comprenant en outre l'étape consistant à envoyer une longue "fin de salve" une fois achevé ledit mode d'écriture, avant le passage audit mode de lecture.

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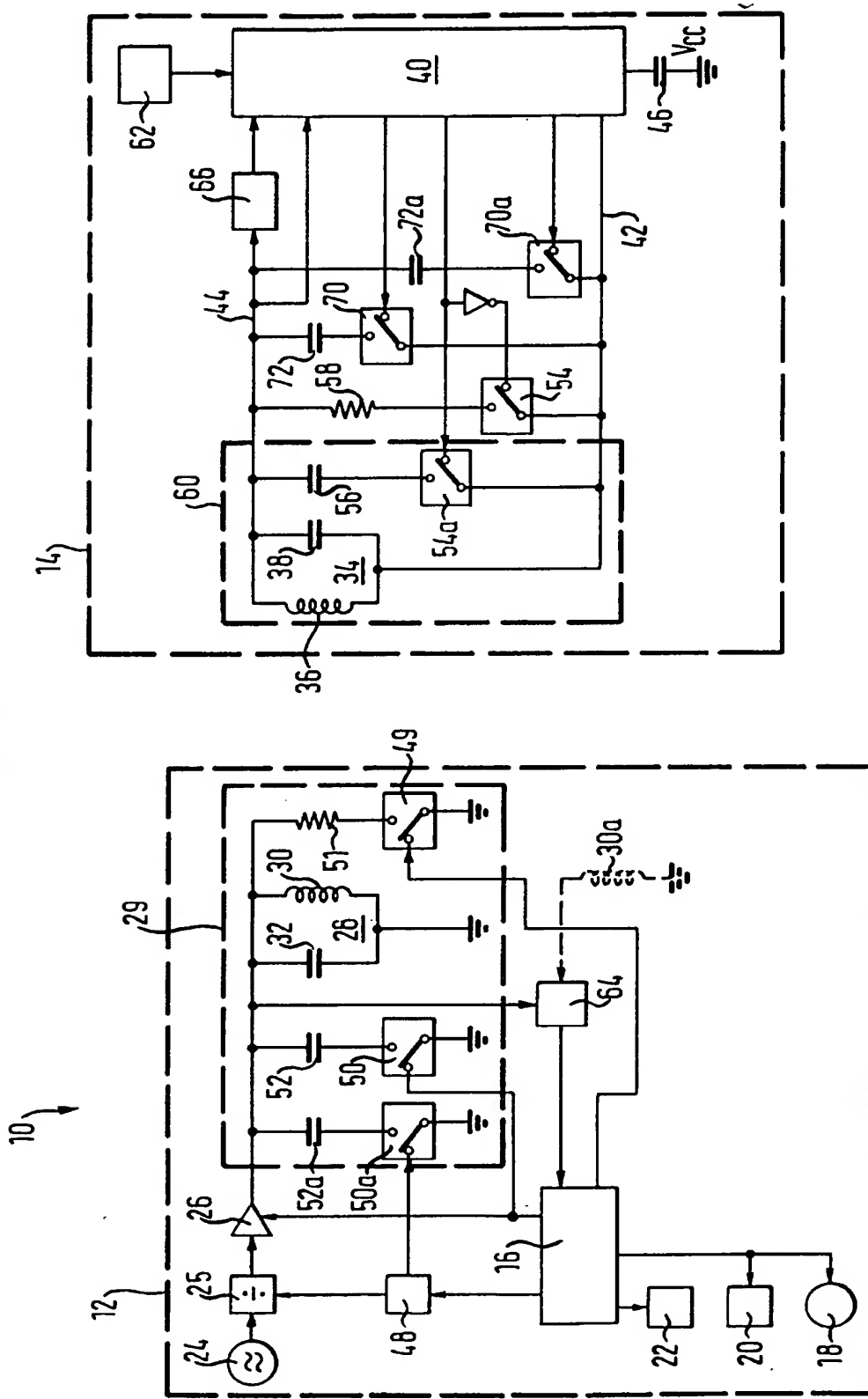
19. Procédé selon l'une quelconque des revendications 14 à 18, et comprenant en outre l'étape d'envoi d'un signal "fin de salve" après l'achèvement de ladite salve d'alimentation.

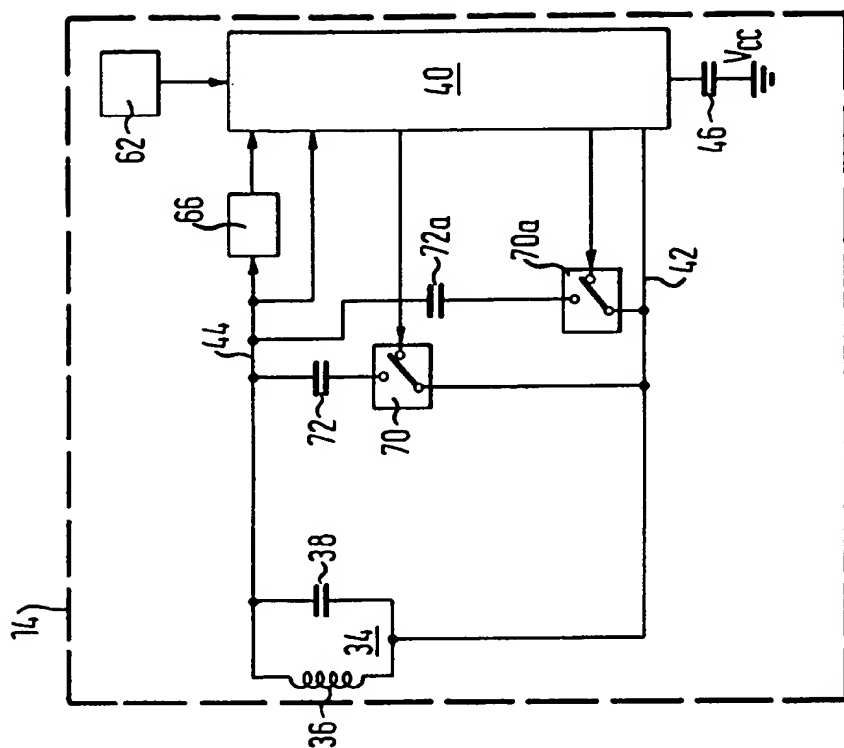
45

50

55

FIG. 1





**FIG. 2**

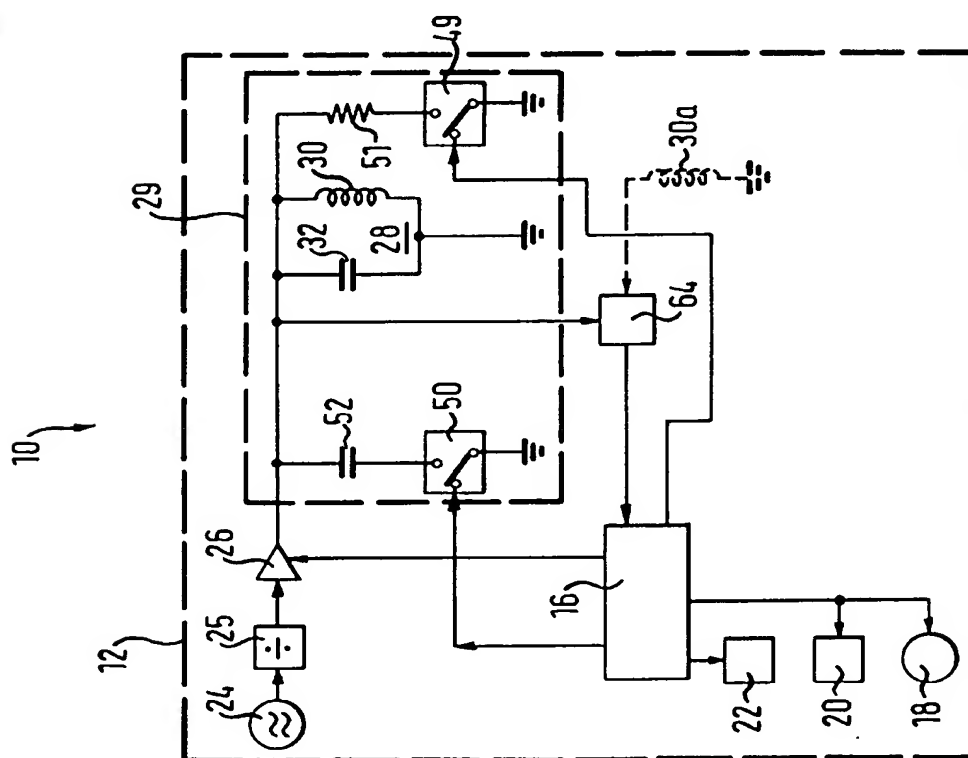


FIG. 3

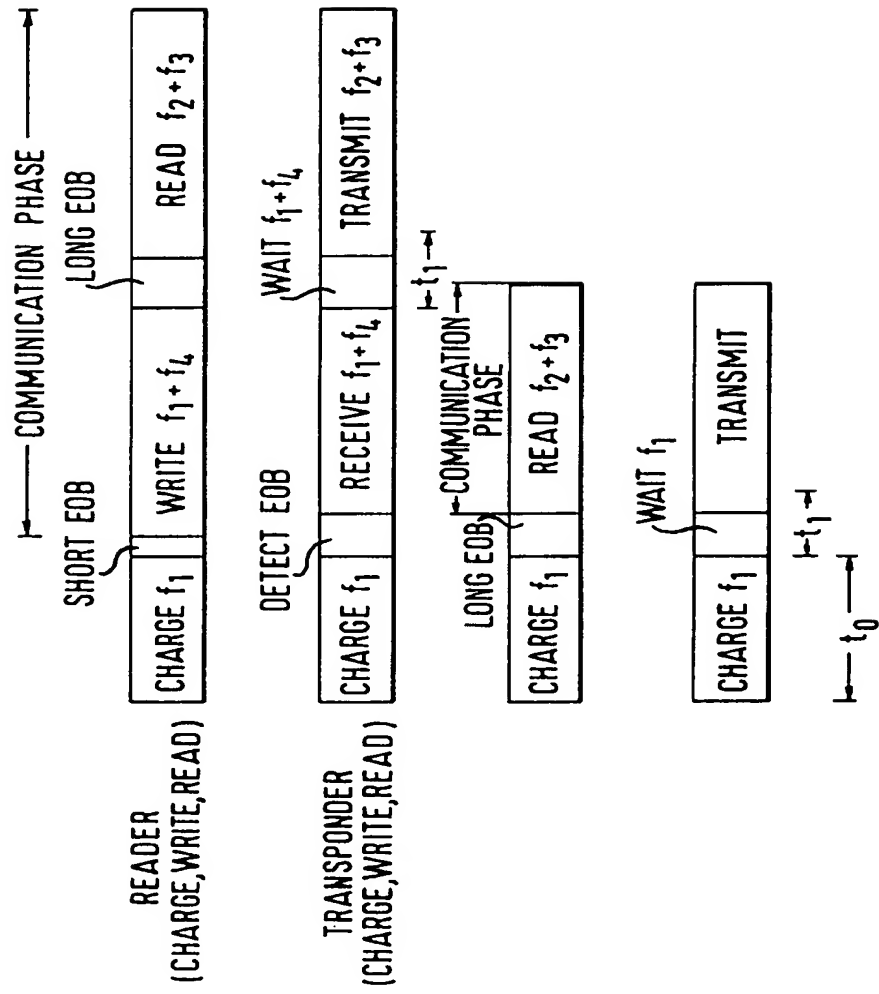


FIG. 4

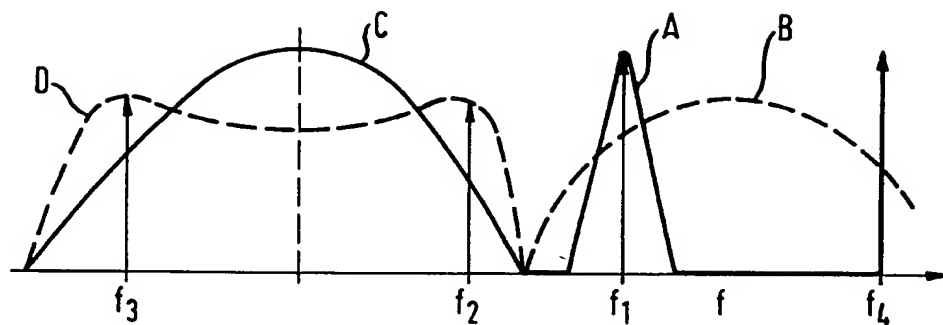


FIG. 5

